Gravina Access Project
Phase I Marine Reconnaissance Technical Memorandum

Agreement No: 36893013
DOT&PF Project No: 67698
Federal Project No: ACHP-0922(5)

Prepared for:

State of Alaska
Department of Transportation and Public Facilities
6860 Glacier Highway
Juneau, Alaska 99801

Prepared by:

Pentec Environmental
Project No. 214-006
120 Third Avenue S, Suite 110
Edmonds, WA 98020

Under contract to:

HDR Alaska, Inc.
712 West 12th St.
Juneau, AK 99801

April 2000

Table of Contents

Appendices

List of Figures (Located Behind Report Text)

1.0 Introduction

The Gravina Access Project is a program evaluating the engineering, economic, and environmental feasibility of various options for providing improved access between Gravina Island and Revillagigedo Island. As a part of this larger project, HDR Alaska, Inc. (HDR), contracted Pentec Environmental (Pentec) to conduct preliminary marine resource and habitat surveys. The overall objective of these surveys was to identify and qualitatively describe habitat types and associated marine resources of ecological or economic concern along the shorelines of Tongass Narrows, including Pennock Island, the west side of Revillagigedo Island from Refuge Cove to just south of the community of Saxman, and the east side Gravina Island from Rock Point to Gravina Point (Figure 1).

The Gravina Access Project is considering a series of options that include bridges, tunnels or sunken tubes, and increased ferry service. Each option requires two or more landfalls involving construction in or across potentially productive littoral (intertidal and shallow subtidal) areas. Tunnels or sunken tubes require construction in deeper waters of the narrows. Pentec investigated 21 areas believed to be representative of shoreline conditions along the Tongass Narrows and surveyed adjacent offshore areas. The surveyed sites encompass the range of littoral conditions present along the narrows and can be used to screen the environmental implications of future crossing options.

2.0 Methods

2.1 Intertidal Surveys

2.1.1 General

A Pentec intertidal ecologist and a phycologist, both highly experienced in Alaskan intertidal flora and fauna, conducted the Phase I intertidal field program January 19 through 23, 2000. An HDR biologist surveyed station GRA-7 on January 27, 2000. Because of the timing of the field reconnaissance with respect to the tidal cycle, we did most of the intertidal work during hours of darkness.

We established a series of intertidal study sites for detailed examination of intertidal assemblages in characteristic habitat types within the study area, based on some preliminary access option identifications provided by HDR. The survey sites represent typical shorelines and subtidal areas that could be crossed by future route options. We described changes in habitats through the intertidal range (i.e., the pattern of intertidal zonation) and characterized dominant biota in each habitat type.

2.1.2 Specific Approach

In the field, investigators typically ranged laterally 30 to 50 meters along the beach to document the range of substrata present at each site and took photographs to document assemblages and habitats encountered. In a limited number of habitats, primarily on bedrock or large riprap, we also described relative abundance of dominants based on randomly placed 0.25-m^2 quadrats. However, we did not conduct quantitative sampling in this phase. For soft habitats (mixed-soft, sand, and mudflat), we characterized the nature of the infauna by excavations with particular emphasis on the presence and relative abundance of harvestable bivalves.

This report describes the pattern of intertidal habitats by zones, based on the dominant substrata and organisms, and approximates tidal elevations based on visual estimates of height above known water surface elevations. We qualitatively describe the benthic assemblages in each distinct habitat zone (e.g., low, mid, and upper intertidal) and include descriptions of the nature of the habitat, dominant macrovegetation, and sessile and motile invertebrates.

Identifications and nomenclature for invertebrates follow O'Clair and O'Clair (1998); those for algae follow O'Clair et al. (1996), Gabrielson et al. 1989, and Scagel et al. (1989).

2.2 Subtidal Surveys

2.2.1 General

A Pentec field crew conducted a preliminary subtidal habitat survey from January 24 through 26, 2000, using Pentec's ***Sea-All™*** video mapping system. The system includes a high-resolution underwater color camera that was lowered on a weighted mount to view the bottom habitat, while a chartered vessel towed the camera slowly along transects. A differential global positioning system (DGPS) provided the coordinates of the camera during the survey. The system superimposed this position, along with the time, on the video image and recorded the data on Hi-8 videotape. The system also recorded these data (approximately once per second) onto the hard drive of the system's navigation computer.

2.2.2 Specific Approach

The investigators ran transects parallel to shore along depth contours. However, small changes in distance from shore often resulted in large changes in depth due to steep and irregular slopes, and when compounded with wind and currents, difficulties sometimes occurred when the boat operator attempted to follow a precise depth contour. As a result, the camera lost sight of the bottom on numerous occasions when the depth under the survey vessel increased more rapidly than we could lower the camera. We ran approximately three transects at different depths at each site, with the shallowest located as close to the beach as was safe and the deepest at approximately -40 ft below mean lower low water (MLLW). On-board scientists made audio notations on the videotape of water depth as indicated by the vessel's depth finder. We later corrected depths into elevations below MLLW using predicted tidal height.

We made copies of the original Hi-8 tape on VHS format videotape for viewing convenience and provided these as a separate submittal. The VHS copies do not provide resolution as high as that provided by the original tapes.

After we completed the field survey, we imported the computer file into a spreadsheet. A biologist reviewed the Hi-8 videotapes and visually described the substratum type noting algal coverage, bull kelp, and sea cucumber presence. We deleted from the computer file data logged during times when the camera was too far from the bottom to view bottom conditions.

2.2.3 Navigation

The field investigators set the video mapping system DGPS for the UTM coordinate system, NAD 83, (North American Datum 1983) meters during the survey to document the location of the video data. After we completed the survey, we imported data from the video mapping system onto the base map provided by HDR. At this time we noted a discrepancy of approximately 200 meters and subsequently found that the base map was in UTM, NAD 27 meters. Since the system had imprinted coordinate data in NAD 83 onto the videotapes during the survey, we corrected the base map into the NAD 83 datum for use in this report. The correction factor used was: +180.05135 meters Northing and -101.99061 meters Easting for the entire mapped area.

We show the subtidal video survey trackline in Figures 2A through 2E. Original and revised names of survey stations are shown in Appendix A, Table 1.

3.0 Results

3.1 General Habitat Types

Tongass Narrows is a relatively narrow channel running between Gravina Island and Revillagigedo Island in southeastern Alaska (Figure 1). The southeastern end of the narrows splits into the East Channel and West Channel around Pennock Island. At the south end of Pennock Island the narrows meets the northern end of Nichols Passage. The northwestern end of the narrows opens into Clarence Strait. The area encompassed by this study extends from Danger Island and the area just northwest of Refuge Cove to the northwest to about halfway down Pennock Island to the southeast.

Tongass Narrows is characterized by strong tidal currents and by steep bedrock or coarse gravel/cobble/boulder shorelines. Lower intertidal and shallow subtidal areas are often sandy or mixed gravel, sand, and shell, with varied amounts of silt (termed "mixed-fine"). At other areas, such as at rocky points and along the northwest shore of Pennock Island, however, bedrock slopes steeply to subtidal depths. Subtidal habitats, like those in the intertidal zone, include a mix of bedrock outcrops or ledges, boulder/cobble slopes, and, where lower slopes permit, sandy gravel bottoms.

Several small natural coves and areas protected by constructed breakwaters provide wave and current protection for anchorages and/or marine habitats with predominantly sandy or gravel bottoms. The largest cove off Tongass Narrows is Ward Cove, where investigations are currently underway to evaluate the effects of wood debris accumulations. Ward Cove was not included in the present study of Gravina Access alternatives.

Extensive areas of riprap bank protection and filling occur along the northeast shoreline of and north of the city of Ketchikan. Construction of numerous buildings on pilings over the intertidal and shallow subtidal zone has significantly modified shorelines in this area. Construction and shoreline protection have similarly modified about a mile of the shoreline of Gravina Island in the vicinity of the airport and airport ferry.

3.2 Intertidal Habitats and Assemblages

3.2.1 General

Pentec surveyed a total of 21 different locations during the January 2000 survey. We have tentatively identified a total of 56 plant and 137 animal taxa from the intertidal areas surveyed. Appendix B provides Tables 1 through 20 listing taxa documented at each site.

In the sections that follow, we summarize the typical assemblages consistently found on each habitat type and elevation. Note that these generalizations are just that, and that many exceptions exist that reflect microhabitats present within each zone. For example, small tide pools in mid or upper rocks typically support plants and animals only found at lower elevations on well-drained rock. These descriptions are followed by more detailed descriptions of specific sites and any unusual conditions (physical or biological) found at each.

3.2.2 Typical Assemblages – Rock, Riprap, and Large Boulders

Upper Zone (e.g., > +8 ft MLLW)

At most rocky sites, including those where the rock consisted of riprap or large boulders, the organisms found at the highest elevations were limpets, usually *Tectura persona* or *Lottia digitalis*, which sometimes occurred as much as a half meter higher on the beach than the highest attached animal, usually the acorn barnacle *Balanus glandula*. This barnacle dominated the upper zone at virtually all rocky sites and was typically accompanied by lesser densities of the smaller barnacles *Semibalanus balanoides* and, especially at lower elevations, *Chthamalus dalli*. Just below the uppermost barnacles, the substrate and the attached fauna were typically covered with rockweed *Fucus gardneri.* Rockweed often achieved 50 to nearly 100 percent cover in some portion of the upper zone. Tufts of the red algae *Gloiopeltis furcata* and *Endocladia muricata* were often present on the exposed tops of rocks and riprap, while other red algae such as *Halosaccion glandiforme* and *Neorhodomela oregona* were sometimes present in moister cracks in the rock in this zone. Other animals often found in the upper zone included other limpets (Lottiidae) and the littorine snails *Littorina sitkana* and *L. scutulata*. *L. sitkana* was most often dominant on natural rock outcrops in association with rockweed, while *L. scutulata* was most often dominant (to several hundred/0.25 m^2) on rock or riprap faces lacking significant rockweed cover.

Middle Zone (e.g., +8 to +4 ft MLLW)

The assemblage on rocky substrates at mid-tide elevations generally included most of the species found at higher elevations, with the addition of several other common taxa. Rockweed and barnacles still covered much of the rock surface, and littorines were often common. The two limpets most characteristic of the highest zones (*T. persona* and *Lottia digitalis*) were seldom seen in the middle zone but were replaced by *T. scutum* and *Lottia pelta* and numerous unidentified smaller lottiids. We often found the large but cryptically colored isopod *Idothea wosnesenskii* in association with the rockweed.

Biological controls on algal cover and animal cover become increasingly important in the middle zone. For example, the cover of rockweed was typically reduced by grazers and, especially during these January surveys, rockweed at lower elevations (i.e., in the lower portion of the middle zone) was often reduced to stipes with a few highly grazed fronds. Also, some areas of the middle zone supported a dense cover of mussels (*Mytilus trossulus*), while at slightly lower levels, this species was eliminated by predation from sea stars (e.g., *Leptasterias epichlora*, *Dermasterias imbricata*) or drills (*Nucella lamellosa*, *N. lima*, *N. emarginata*). In addition to these predators, other species found more commonly in the middle zone included the thatched barnacle *S. cariosus* and red algae such as *H. glandiforme*, *Mastocarpus papillatus*, *Neorhodomela larix*, and *N. oregona*. Encrusting red alga such as *Hildenbrandia rubra* and *Gloiopeltis* base or "*Petrocelis*" were often abundant.

Areas around tide pools or under overhanging ledges in this zone often included many species common in the lower rocky zone, while the pools themselves often supported sharpnose sculpin (*Clinocottus acuticeps*), heptacarpid shrimp, and hermit crabs (mostly *Pagurus hirsutiusculus*).

Lower Zone (e.g., +4 to -4 ft MLLW)

The lower rocky intertidal zone along Tongass Narrows (and elsewhere) was substantially more diverse than other habitats surveyed, except for the low boulder fields that included most of the species characteristic of lower rocky habitats as well as species present in the surrounding mixed-fine substrata (see Section 3.2.4). This diversity was heightened in areas below about MLLW, where many species that are essentially subtidal in habitat preference were found. In these lower areas, algae present during the winter were highly diverse but represented primarily by small individuals representing the next year's recruits, or by tattered senescent individuals from the previous year's growing season. Some typical new recruits included the sea lettuce *Ulva fenestrata*, and the reds *Neodilsea borealis*, *M. papillatus*, *N. oregona*, and *Cryptosiphonia woodii*. Remnants of last year's kelp *Laminaria* and *Cymathere triplicata* were often encountered along with the reds *Constantinea subulifera* and *Palmaria* spp. Encrusting and articulating coralline algae (e.g., *Corallina frondescens*) often occupied a large percentage of the rock surface, and grazers on these forms, especially the chiton *Tonicella* spp., were often common.

Intense predation by a variety of sea stars (*Leptasterias*, *Pycnopodia helianthoides*, *Dermasterias*, *Henricia leviuscula*, *Evasterias troschelli*, *Mediaster aequalis*, *Orthasterias kohleri*) and gastropods (*Nucella* spp., *Searlesia dira*, *Ceratostoma foliatum*, *Trichotropis insignis*) limited the numbers of attached barnacles or bivalves. The rock surface was typically occupied by encrusting coralline algae or other encrusting forms such as bryozoans, serpulid polychaetes (*Serpula vermicularis*, *Pseudochitinopoma occidentalis*), spirorbid polychaetes, sponges (e.g., *Halichondria panacea*), and tunicates (e.g., *Cnemidocarpa finmarkiensis*, *Aplidium californicum*). Rock jingles *Pododesmus macroschisma* and anemones (*Metridium* spp.) were often present on sheltered undersides of ledges. We found the large black chiton *Katharina tunicata* in shallow depressions or crevices in the rock at lower and lower middle elevations. Several other taxa of tunicates, nudibranchs, gastropods, and other groups were present, although their numbers were seldom high.

3.2.3 Typical Assemblages – Cobble and Gravel

Upper Zone (e.g., > +8 ft MLLW)

Upper intertidal cobble and gravel beaches tended to have a limited biota except on larger cobbles, which often had low densities of barnacles or littorines. Moist areas under cobbles typically collect bits of organic matter, and these areas harbored gammarid amphipods and shore crabs (*Hemigrapsus nudus*).

Middle Zone (e.g., +8 to + 4 ft MLLW)

Middle intertidal cobble and gravel beaches supported an increased epibiota and flora compared to higher elevations. Rockweed and *Mastocarpus* were typical plants in this assemblage; barnacles were likely to be more abundant than at upper elevations and under-rock animals were often very abundant and joined by hermit crabs and, occasionally, *Leptasterias*, and fish of the families Pholidae or Stichaeidae. Mussels and barnacles were often more abundant on cobbles or boulders at lower elevations than they were on steeper rocky shores, because the lower slope of these beaches provides some refuge from sea star predation. Areas with higher concentrations of silt and organic matter in the sediment supported an infauna including a few littleneck clams (*Protothaca staminea*) and a limited number of polychaetes.

Lower Zone (e.g., > + 4 ft to -3 ft MLLW)

Lower cobble gravel beaches in Tongass Narrows comprise a wide variety of microhabitats that contribute to a diverse biota. The diversity of substrata allows for attachment of a diversity of algae, which in our survey included several laminarians and a number of foliose and filamentous reds. Larger rocks (cobbles or boulders) supported most of the diverse epibiota described in lower rocky habitats, along with a more diverse under-rock fauna that included gammarids; the crabs *Petrolisthes eriomerus, Lophopanopeus belli,* and *Cancer oregonensis;* jingles; the cucumber *Cucumaria miniata*; and the hermit crabs *Pagurus beringanus* and *P. granosimanus*. Pholid or stichaeid fish were more abundant at lower elevations, and the dorid nudibranch *Onchidoris bilamellata* was usually present, often in spawning aggregations. We usually found two or more species of chitons (*Mopalia* spp.).

3.2.4 Typical Assemblages – Sand, Mud, and Mixed-Fine

Upper Zone (e.g., > +8 ft MLLW)

Upper intertidal sand or mud beaches are not widely distributed in Tongass Narrows. Where seen, sandy gravel at higher elevations reflect wave energies that preclude establishment of a significant biota. We found exceptions where sand or mud pockets existed above rocky ledges that tended to retain water and protect the finer-grained substratum from wave action. In these areas, we saw a few infaunal species, most notably the softshell clam *Mya arenaria.*

Middle Zone (e.g., +8 to + 4 ft MLLW)

Where the beach is sufficiently sheltered to maintain its stability against wave action and where fines and organic matter can accumulate within the coarser gravel/sand sediment matrix (defined as mixed-fine), we found an increasing number of animals living within the sediment. The abundance of infauna in the middle intertidal zone is highly dependent on the presence of finer materials and on the degree of water retention during low tide. The dominant infaunal species in the middle intertidal zone in areas of mixed gravel and silt was the littleneck clam *P. staminea*. Polychaetes such as nerieds and glycerids also became increasingly abundant at lower elevations.

Mussels were often well-established in the gravel surface of mixed-fine beaches with their byssus threads serving to stabilize the surface gravels, thus allowing the attachment of rockweed and barnacles with their associated gammarid amphipods, isopods, limpets, littorine snails, and hermit crabs (*P. hirsutiusculus*).

Lower Zone (e.g., > + 4 ft to -3 ft MLLW)

Lower-elevation mixed-fine beaches along Tongass Narrows often occur below mid-intertidal rock or boulder/cobble beaches and often have scattered boulders supporting the typical lower-elevation biota described above. Depending on the degree of predation by sea stars and naticid snails (*Cryptonatica affinis, Polinices lewisii*), these areas often had very high densities of littleneck and butter (*Saxidomus giganteus*) clams. We estimated that densities of these hardshell clams were as high as 40/0.25 m² in several areas. Mixed-fine beaches support a diverse and abundant infauna as well. Several families of polychaetes were well-represented (e.g., Glyceridae, Capitellidae, Opheliidae, Nereidae, Chaetopteridae, Oweniidae) along with the burrowing cucumber *Chiridota discolor* and the peanut worm *Phascolosoma agassizii*.

At locations where the lower mixed-fine or sand bottom extended subtidally, beds of eelgrass *Zostera marina* were present. We found eelgrass as high as about +1 ft MLLW in one area. A wide range of research (e.g., McRoy 1970, Phillips 1984, Fonseca 1992) has shown eelgrass beds to be highly productive and to provide a variety of important ecological functions as nursery areas for juvenile salmon and Dungeness crab (*Cancer magister*) and as a substrate for spawning by Pacific herring (*Clupea pallasii*).

3.2.5 Site-Specific Habitat Conditions

GRV-1 – Ohio Point

The upper beach at this site is bedrock and boulders that thin to the south as the mixed gravel/sand lower beach expanded upward. The biota on the rocks and boulders was rich and typical for the elevations (Appendix B, Table 1). The lower mixed sand and gravel supported a limited infauna; only a few peanut worms (*P. agassizii*) were seen.

GRV-2 – 1-Mile Range

This site lies in a shallow cove about one-half nautical mile southeast of the 1-mile range marker at Ohio Point. At the lowest elevation surveyed (about -3.7 ft MLLW) at the center of the cove was a coarse sand and angular gravel with moderate quantities of silt and a redox discontinuity at about 3 cm. This area had few clams, probably because of intense predation, but we found littlenecks and *Macoma incongrua* along with glycerid and capitellid polychaetes, ophiuroids, and occasional large nemerteans (*Cerebratulus* sp. and *Paranemertes peringrina*) (Appendix B, Table 2). These species and assorted polychaetes were also found to the north where the beach became increasingly sandy and to the south where increasing numbers of cobbles and boulders were present. Other species in this lower mixed-soft beach included horse clams (*Tresus capax*), butter clams, and peanut worms. North of the innermost part of the cove and just south of the rocky point sheltering the cove from the north, a small runoff channel crossed the beach and was filled with clam shells.

Higher elevations throughout this site became increasingly bouldery (southern portion) or rocky (northern portion), and we observed biota typical for the substrate and elevation.

GRV-3 and GRV-4 – Lewis Cove N and S

These sites lie just off the northwest end of the Ketchikan airport runway in an embayment partially protected from the northwest by Lewis Point, from the south by the shoreline configuration, and to the east (at low tide) by a rock reef. A small stream (No. 10450) flows into the head of the cove through an area of brackish and salt marsh. The northern end of the area surveyed had a silty sand lower beach (near MLLW) with abundant eelgrass that extended for some distance subtidally. Probably because of its protection from wave action, this site had among the richest infaunas of any site surveyed (Appendix B, Table 3). A large variety of polychaetes and bivalves (littlenecks, butter clams, cockles [*Clinocardium nuttalli*]) were present. A high degree of patchiness in infaunal abundance was evident, with a less rich fauna in less organic and fine-grained sediments higher on the beach and very high densities of littlenecks (to about 50/0.25 m^2) in siltier areas to the south. Higher on the beach, the substratum had increasing numbers of cobbles on the surface and had the typical rockweed, barnacle, limpet and littorine assemblage with the typical under-cobble species. Mussels were embedded in the mid-tide range beach sediments over much of the area.

At the south end of the cove (GRV-4), the lower beach still supported fair numbers of littlenecks, but densities varied greatly as a result of dynamically moving gravel sand berms. As these phenomena migrate up the beach driven by waves, they progressively bury existing infauna and provide new sediment for colonization by a new infauna. Mid-tide elevations on this beach were similar to those described above. The meandering creek entered saltwater along the east side of the mid-tide beach; a high-elevation spit and storm berm at the head of the cove protected the creek mouth and supported a fringe of saltmarsh and dune vegetation (e.g., *Carex*, *Deschampsia*, *Elymus*). The creek mouth itself was covered by a broad ice shelf that rested on the intertidal.

GRV-5 – Barge Dock

This site was surveyed at the end of a riprapped fill north of the seaplane dock and boat ramp in the cove just north of the airport terminal area. Riprap extended down to below the water surface at the time of the survey; a coarse mixed gravel and cobble bottom appeared to begin at about -1 ft MLLW. The larger riprap around the site contained biota typical for the habitat and elevations (Appendix B, Table 4). Smaller riprap on the east face of the fill (apparently placed to allow barges to approach the beach) had a less rich biota than is typical on larger riprap.

The beach in the vicinity of the boat ramp was briefly surveyed and had a rich infauna of polychaetes and hardshell clams (littleneck and butter) at about +2 to +4 MLLW.

GRV-6 – Airport

This site was surveyed on large riprap just south of the ramp to the new airport floatplane dock. Biota on the riprap was typical for the substratum and elevation, except that pandalid shrimp (*Pandalus* sp.) were common in the water among the lowest riprap (Appendix B, Table 5).

GRV-7 – Clump Island

General conditions at this site were surveyed on January 27 during a +3.3 ft MLLW tide. The site had generally moderate slopes, and the dominant substratum was boulder/cobble with patches of coarse sand and shell. The boulder/cobble beach supported dominant biota typical for the substratum and elevation, with increasing coverage of rockweed and barnacles at higher elevations. More sandy gravel, supporting less epibiotal species, was present at higher elevations and nearer the mouth of Government Creek (Appendix B, Table 6). Sandy upper intertidal elevations adjacent to the stream mouth had patches of saltmarsh vegetation (e.g., *Carex*).

GRV-8 – Tugboat

The intertidal site just shoreward and south of the beached tugboat in the West Channel around Pennock Island had a relatively high diversity of habitats ranging from relatively clean sand, mixed-fine, and boulder fields at the lower elevations (e.g., below MLLW) to clean gravel cobble and bedrock outcroppings at mid-tide and upper elevations. The lower habitats were uniformly rich in epibiota, both plants and animals (Appendix B, Table 7). Moderately high densities of hardshell clams (littleneck and butter) were present in the lower mixed-soft substrata.

GRV-9 – West Channel SW

This site encompassed a broad intertidal boulder/cobble bench with large areas of sand and gravel (mixed-soft) and limited areas of bedrock outcrop. Like GRV-8, the lower elevations were extremely rich in species. Large (1- to 2-m-high) boulders added to the habitat diversity and created a variety of micro-niches supporting the great majority of taxa found at lower elevations anywhere in the narrows (Appendix B, Table 8). Mid- and upper-elevation cobble and rock outcroppings supported biota similar to those found elsewhere on similar substrata.

REV-1 – Refuge Beach

Refuge Beach lies just north of Refuge Cove at a small park. The beach had a complex mixture of habitats ranging from bedrock ledges, to mixed-fine sand and gravel, to mud pockets. The lower edge of the beach below about -3 ft MLLW was mixed-fine with eelgrass. The intertidal zone was crossed by a concrete outfall pipeline that provided a hard substratum well-colonized by epibiota. The rock ledges and the concrete outfall pipe at various elevations supported a biota typical for their respective elevations (Appendix B, Table 9). A muddy sand pocket above the uppermost rock ledge had infaunal species typical of high elevation mudflats that are rare in Tongass Narrows. The dominant mixed-soft animal was the softshell clam *M. arenaria*. Lower-elevation rock at this site had among the most diverse biota found at any site. Water over lowest mixed-fine and eelgrass habitats that were still flooded at a -3 ft tide had very high densities of pandalid shrimp (probably *Pandalus danae*) and a variety of crab including *Pugettia productus, Cancer productus,* and *Oregonia gracilis.*

REV-2 – Floatplane Dock

This intertidal site was surveyed under and just south of the stairs and ramp leading to the State of Alaska floatplane dock at the southern entrance to Ward Cove. The upper beach under the ramp was bedrock that slopes steeply down to the rubble and cobble beach below. Farther to the south, the upper beach was rubble and cobble with areas of mixed-fine substratum under the rubble in some places. The rock fauna was typical for the elevations, with a high density of limpets (*T. persona*) at the highest elevations and nearly 100-percent coverage of rockweed in the middle elevations (Appendix B, Table 10).

REV-3 – Propane Dock

The intertidal site surveyed was centered on a near-vertical riprap wall at the propane dock just shoreward of the R “10” buoy. The toe of the vertical riprap was at about 3.4 ft MLLW at the northern corner and somewhat higher at the southern corner of the propane dock fill. Large riprap boulders were scattered at the base of the vertical riprap and rested on a sandy gravel and shell bottom. The riprap and the boulders along its base supported a biota similar to that on other riprap at similar elevations (Appendix B, Table 11). The creosote-treated pilings of the dock, especially diagonal piles providing lateral stability to the dock, supported a dense epibiota dominated by large thatched barnacles and mussels that were not seen in abundance on the adjacent riprap at the same elevations. Clearly, the sloping pilings provided these animals a refuge from sea stars that control their distribution on the adjacent riprap.

Small coves to the north and south of the dock were also examined. These areas had a more natural beach of gravel and cobble with limited fines and a fauna typical of cobble/gravel beaches along the narrows.

REV-4 – North Dump

This site is at the base of riprap encasing a former dump, and the beach was littered with iron, wire, glass, and other debris. Riprap and rock extended into the water at a -1.5-ft tide, but a small pocket beach of gravel, sand, and debris remained to the north. Biota was typical for the substratum and elevation except that excavations into the limited beach area did not reveal any significant infauna (Appendix B, Table 12).

REV-5 – Riprap Cove

This was the most recently disturbed of any sites surveyed. The substratum was largely riprap or quarry spalls, and much of the area appeared to have been recently disturbed by activity at an adjacent work area. As a result of recent instability, the middle and upper intertidal areas were relatively impoverished; lower elevations were not accessible because of the tide during the survey (Appendix B, Table 13). A high-elevation constructed bench of quarry spalls appeared to be recently placed and was barren.

REV-6 – Bar Point

The intertidal site surveyed at Bar Point included the upper portion of a rocky reef flat that extends out beyond the riprap fill forming a large commercial development southeast of the Bar Point marina breakwater. Lowest tide during the survey was +2.5 ft MLLW, so that only middle and upper intertidal zones were surveyed. The biota on the rock bench and lower riprap was typical of rocky habitats at the same elevations (Appendix B, Table 14). On the rock bench, the outer and lower portions had a relatively sparse growth of highly grazed rockweed; at higher elevations on the bench the rockweed was much more robust, covering up to 80 percent of the surface in some areas. Overall, the rocky bench was remarkably rich. The infauna in the limited areas of mixed-fine habitat around the upper base of the rocky bench and along the adjacent riprap included burrowing cucumbers (*Chirodota*) and high densities of hardshell clams (*P. staminea*). Biota on the riprap was typical for the area and elevation.

REV-7 – Thomas Basin

The intertidal portion of this site consisted entirely of riprap along the face of the breakwater and parking lot at the entrance to the Thomas Basin marina. Because the rock faces to the south and is subject to higher desiccation rates, the biota was relatively impoverished (Appendix B, Table 15). One anomaly at this site was a sea lemon (*Archidoris montereyensis*), a species not commonly reported from this latitude.

REV-8 – South Dump

This site was remarkable in that the mixed gravel sand beaches interspersed between and below the rock benches occupying much of the site were covered with debris, predominantly broken glass and metal. Some areas of rocky bench had accretions of 1 to 2 ft of fused metal waste that elevated the substratum and were themselves colonized by typical rock-dwelling biota (Appendix B, Table 16). The site was similar to REV-6 in having heavily grazed rockweed at the lower elevations (e.g., +2 to +3 ft MLLW) and healthy rockweed covering up to 100 percent of the rock surface at higher elevations.

PEN-1 – Radenbough Cove

Radenbough Cove is a shallow, reef-protected cove on the northeastern shore of Pennock Island. The center of the cove at about MLLW to -2 ft MLLW, as viewed through the water column, appeared to be a mixed-fine bottom of sand and shell. We saw eelgrass. The intertidal area surveyed around most of the cove was also mixed-fine with scattered cobble. At the lowest elevations surveyed (about +4 ft MLLW), little infauna was present in the sediments, but the presence of shells of littleneck and butter clams suggested that these species would be found at lower elevations. The mixed cobble/gravel middle and upper beach had the typical taxa for the elevations (Appendix B, Table 17). Mussels were abundant in the surface of the gravel in the middle zone.

PEN-2 – East Channel SW

This site lies on the eastern shoreline of Pennock Island, just south of Whiskey Cove. Relatively steep bedrock ledges break to the south into boulder fields. Littleneck clams were abundant in pockets of sand and gravel among the boulders (Appendix B, Table 18). The epibiota on the rock and boulder substrata was typical for the elevation, with high densities of the sea star *D. imbricata* and the drill *S. dira* (Appendix B, Table 18).

PEN-3 – West Channel SE

This site, located on the northwest shore of Pennock Island across the channel from the sunken tugboat, had a series of rock ledges that extend down to about MLLW or higher. Below the bedrock was a mixed-fine beach, which had abundant polychaetes, littleneck and butter clams, and other infauna (Appendix B, Table 19). The bedrock was highly rugose with a rich epibiota including cover of encrusting coralline algae and somewhat higher densities of the black chiton *K. tunicata* and the purple sea star *Pisaster ochraceous* than seen on other rocky habitats at similar elevations (Appendix B, Table 19).

PEN-4 – West Channel NE

This site, located on the northwest shore of Pennock Island opposite the channel marker buoy, was steep bedrock and slabs that slope into deep water. Because of the shading of overhanging trees and the western exposure of this site, it had limited algae at the upper elevations and was, uncharacteristically, nearly devoid of rockweed (Appendix B, Table 20). As a result, the upper rocks were dominated by barnacles, primarily *C. dalli*. At lower tide levels, however, a rich epibiota was present. Rock slabs extending subtidally and crevices under large overhanging rock slabs supported a number of taxa not found, or rare, elsewhere in the narrows (e.g., the coral *Balanophyllia elegans*, the erect bryozoan *Dendrobenia lichenoides*, the scallop *Chalmys hastate*, the gastropod *Scabrotrophon maltzani,* and the sea peach *Halocynthia auranthium*).

3.3 Subtidal Habitats and Assemblages

3.3.1 General

Subtidal margins of Tongass Narrows are characterized by steeply sloping bedrock or coarse gravel/cobble bottoms extending from the lower intertidal zone to the deeper, flatter center of the channel at depths of -80 to -150 ft MLLW. For the most part, these subtidal slopes are swept by strong tidal currents and support a number of kelp and other algal species down to depths of about -40 ft MLLW. The primary algal taxon observed in the January surveys was *Laminaria*, which covered much of the bottom. In spring and summer many of these rocky areas support a canopy of bull kelp (*Nereocystis luetkeana*), but we saw only remnants of this annual species (down to about -30 ft MLLW) in these surveys. At depths below -40 ft MLLW, the bottom became nearly barren sand and gravel.

Shallow subtidal areas that are protected from direct impact of the currents in small coves or behind breakwaters had more gradually sloping sandy bottoms that often supported healthy eelgrass beds (Figures 3A through 3E). Sea cucumbers (*Parastichopus californicus*) were seen at several locations (Figures 3A through 3E). Otherwise, very few vertebrate or invertebrate organisms such as fish or crab were observed during the survey. This may be due in part to the necessity of keeping the video camera well above the bottom because of the steep and irregular bottom terrain.

We used the video mapping system to visually characterize substrate types (see Figures 2A through 2E).

3.3.2 Site-Specific Habitat Conditions

Danger Island

This island is a large bedrock outcropping in the channel opposite Refuge Cove. The rocky bottom dropped quickly a short distance offshore turning into a sand and shell substrate. Large *Nereocystis* beds occurred along the rocky shoreline of the island, and extensive areas were covered with *Laminaria*. Numerous sea cucumbers were present.

Channel Island

Channel Island is a bedrock outcropping near the center of the channel, due south of Danger Island. The rocky bottom dropped steeply, being near-vertical in places. In the deeper areas near the island, the bottom substrate was gravel, cobble, and shell debris. Extensive areas were covered with *Laminaria*, and *Nereocystis* beds lined most of the rocky shoreline of the island. A large patch of sea cucumbers was present.

GRV-1 – Ohio Point

The bottom at this location appeared to be sand with patches of gravel and shell debris. Large numbers of sea cucumbers were seen and large patches of *Laminaria* covered the bottom.

GRV-2 – 1-Mile Range

The bottom at this location was sand with patches of gravel and shell debris. We observed aggregations of sea cucumbers. *Laminaria* was common in the patches with coarser substrata.

GRV-3 – Lewis Cove N

The bottom substrate in the area surveyed was gravel and shell debris with trace amounts of *Laminaria*. A large but patchy eelgrass bed extended along the shoreline in a nearly continuous band to the south toward GRV-4. This eelgrass bed may have been continuous with the eelgrass seen in the intertidal survey.

GRV-4 – Lewis Cove S

Shallow depths and a rock reef protecting this cove prevented the survey vessel from entering. Offshore, the bottom was a mixture of gravel and sand with a continuation of the large eelgrass bed seen at GRV-3. In the deeper areas, *Laminaria* dominated the bottom habitat.

GRV-5 – Barge Dock

A continuation of the band of eelgrass beginning at GRV-3 was present as a nearly continuous band of eelgrass just offshore of the riprapped beach along the airport at GRV-5. A band of *Nereocystis* paralleled the beach inside of the eelgrass bed. Offshore, a nearly continuous mat of *Laminaria* was present. We also saw sea cucumbers along this shoreline.

GRV-6 – Airport

The band of eelgrass along the southwest shore of the Tongass Narrows continued south to just north of the new floatplane dock (Figure 3B). Here, the eelgrass was just offshore of the riprapped beach. Nearer the shoreline there was also a band of *Nereocystis*, which was probably attached to the lower portions of the riprap. *Laminaria* was also common.

GRV-7 – East Clump Island

The area in the vicinity of East Clump Island is a "boat graveyard" with numerous sunken vessels. The sand, gravel, and shell bottom was littered with debris. We observed small amounts of eelgrass; however, for safety reasons the survey vessel could not investigate close to shore. It is likely that the eelgrass bed was somewhat larger than indicated by the video survey, especially shoreward from the video trackline. Small patches of *Laminaria* also were present.

GRV-8 – Tugboat

A large sunken tugboat served as a landmark at this site at low tide and is a significant navigation hazard at high tide. The bottom was sand and gravel with occasional rocky outcroppings supporting small patches of *Nereocystis*. We observed considerable numbers of sea cucumbers, especially near the middle of the channel.

GRV-9 – West Channel SW

Bathymetric contours were uncharacteristically gentle at this location. The bottom was sand or gravel and shell with outcroppings of bedrock. We observed occasional remnants of *Nereocystis* in the vicinity, probably attached to the rocky outcroppings. Small numbers of sea cucumbers were present and *Laminaria* was common.

REV-1 – Refuge Beach

The subtidal bottom at this site was sandy with broken shell debris. We detected only a small area of eelgrass in spite of the relatively protected nature of the site. Small numbers of sea cucumbers were also present.

REV-2 – Floatplane Dock

This site is sheltered from strong southerly winds. The bottom was mostly a sandy substrate with patches of gravel and shell debris, although the survey vessel nearly struck a very large boulder at the north edge of the surveyed area. We found a patch of eelgrass north of the floatplane dock, and eelgrass probably extends along the shoreline to the north of the surveyed area. *Laminaria* was common.

REV-3 – Propane Dock

The bottom substrate in this area was predominantly gravel and shell debris with considerable coverage of *Laminaria*. We found a small patch of eelgrass just offshore of the notch between the propane unloading pier and the landfill to the north that is protected with walls constructed of large boulders.

REV-4 – North Dump

This site is just north of a former garbage dump, and large amounts of scrap steel litter the beach and bottom. The beach dropped very quickly into deep water. Bedrock outcroppings and patches of cobble supported large patches of *Laminaria.*

REV-5 – Riprap Cove

The subtidal bottom at this location was similar to that at REV-4, with large amounts of debris from the former dump site and patches of *Laminaria* on a steeply sloping rock and cobble bottom.

REV-6 – Bar Point

This site covers a large, shallow reef east of the breakwater that protects the Bar Point Basin marina. The bottom was primarily sand or a mixture of sand, sand and gravel, and patches of cobble. We found patchy eelgrass growing at this site and *Laminaria* covered a large portion of the bottom area.

REV-7 – Thomas Basin

This site lies along a riprap breakwater that protects a marina. The water depth increased rapidly along the face of the breakwater, and the bottom was primarily sand and shell debris. *Laminaria* dominated the area, but small patches of eelgrass also were present. Submerged, broken-off pilings created a navigation hazard in the area.

REV-8 – South Dump

This site appeared to have been a garage dump and metal debris littered the bottom. The substratum was sand or gravel and shell debris. The bottom supported a nearly continuous mat of *Laminaria*.

E Deep

An attempt was made to videotape the deeper parts of Tongass Narrows between REV-6 and GRV-7. We found that the weight on the camera was too light to effectively perform this task, and we encountered considerable difficulty in keeping the camera within sight of the bottom. The limited views of the bottom indicated that the bottom was nearly barren with a sandy substrate.

PEN-1 – Radenbough Cove

Due to large boulders and a rock reef off the mouth, the survey vessel could not enter Radenbough Cove. Instead, we surveyed an area offshore of the boulder field where the bottom substrate was sand and shell. Bedrock outcroppings also were present, and large patches of *Laminaria* were the dominant biological feature.

PEN-2 – East Channel SW

The bottom at this site was sand and shell with extensive areas of *Laminaria*.

PEN-3 – West Channel NE

The bottom was sand or sand and shell and appeared to be heavily scoured by strong currents. *Laminaria* beds were the primary biological features.

PEN-4 – West Channel SE

This area had a sandy bottom with an occasional boulder. Small areas of *Nereocystis* were observed nearshore at the surface of the water. Only trace coverage by *Laminaria* was seen, and some anthropogenic debris was also observed.

4.0 Discussion

4.1 General Habitat Types

Littoral (intertidal and shallow subtidal) areas along the Tongass Narrows represent a range of habitat types from sand and gravel to bedrock. Because of the geology and the strong currents in the narrows, mud habitat is very limited in the area surveyed. The majority of natural beaches surveyed had bedrock outcrops in some portion of the intertidal zone; often an area of fractured bedrock or boulders also would be present. When present, sediment was largely coarse gravel or sand; only in the more sheltered areas or in the lowest intertidal zone was there a significant percentage of fines present. A substantial portion of the northeastern shoreline of the narrows between stations REV-8 and REV-2 has been modified by riprap, bulkheading, and/or construction of overwater structures.

4.2 Characteristic Biological Conditions

The biota found in each of these diverse habitat types was generally typical of biota found over a larger ecoregion (e.g., Ricketts and Calvin 1962). More specifically, the biota was typical of that expected for this area of southeast Alaska. Quast (1968) characterized inside waters of southern southeast Alaska as being warmer than northern inside waters but with lower salinity than outside waters of the Panhandle, and he recognized each region to harbor a distinctive association of fishes. Lindstrom and Foreman (1978), Lindstrom et al. (1997), and Lindstrom (unpublished data) have noted the similarity of the seaweed flora of the Ketchikan area to that of the Strait of Georgia in southern British Columbia, another area of relatively warm, low-salinity water.

Several taxa identified in this survey may not have been previously reported in the Ketchikan area. We found the highest standing crop of algae, primarily rockweed, in the mid to upper intertidal zones which had stable boulders or bedrock. Despite the mid-winter survey timing, many of these areas had densities of rockweed approaching 100 percent coverage. At lower intertidal elevations, grazing, probably by limpets and snails (*Littorina* and/or *Lacuna*), greatly reduced the standing stock and apparent health of rockweed. Lowest intertidal and shallow subtidal rocky and boulder habitats in areas of high current had the richest epibiota found in the study area. In these areas, biological controls, primarily sea star and gastropod grazing, maintain the assemblage composition (e.g., Paine 1966).

On the Ketchikan side of the narrows and near the airport, riprap, placed to build additional useable uplands or to protect existing shorelines from erosion, provides an artificial rocky shoreline. Riprapped areas display an epibiota generally similar to, but usually less diverse than that on natural rocky shores. Because riprap consists of angular boulders stacked on top of one another (rather than boulders set in a gravel matrix, as is often the case in nature), individual boulders lack continuity with the adjacent substratum. Also, riprap rock typically lacks consistent patterns of cracks and crevices that retain water or sediment in miniature tide pools and tends to retain little moisture between tides. For example, rockweed tends to be abundant on the tops and north or east faces of riprap boulders and absent or scarce on sloping, south or west faces which dry out between tides during the summer.

On gravel and sand substrates, presence and abundance of epibiota is dependent on the elevation, size, and stability of beach materials. In more energetic intertidal and subtidal gravel and sand bottoms, little epibiota is present. However, during periods of relatively low wave energy and high light levels, these areas may develop a substantial microflora that can support productive epibenthic zooplankton populations. These zooplankton, primarily amphipods and harpacticoid copepods, are important prey for juvenile salmonids during their early marine life history (e.g., Simenstad et al. 1982). Cobbles resting on a gravel beach support some of the more interesting animals in the mid to lower intertidal range, including mobile scavengers that leave the protection of the cobble during high tide to forage over adjacent beach areas. This under-rock biota includes several species of amphipods, crabs, and fish.

In protected or semi-protected areas, varying amounts of finely divided organic matter or silt-sized inorganic particles can accumulate in the sand/gravel matrix. Such areas support a diverse infauna, typically dominated by polychaetes and bivalves. In study sites surveyed in Tongass Narrows, areas with higher proportions of fines in the gravel sand matrix often had moderate to high densities of edible hardshelled clams including butter clams and littlenecks.

Eelgrass beds are present throughout the project area on gravel, sand, and silty sand bottoms from MLLW to subtidal depths. Eelgrass beds and adjacent gravel, sand, and mud mixed-soft beaches provide habitat for epibenthic zooplankton in spring and summer and are highly important rearing areas for juvenile salmonids during their early marine life history (Simenstad et al. 1982). Eelgrass beds also provide important rearing areas for numerous other species including Dungeness crab and are often used as a substrate for spawning by Pacific herring.

In subtidal habitats, the study design placed emphasis on mapping key habitat types, biota, and substrates. The most important resource mapped was eelgrass. Small patches or larger beds of eelgrass were present in most areas surveyed that had appropriate substrates (small gravel or sand) at appropriate depths (e.g., +1 ft to about -20 ft MLLW). The largest beds begin along the shoreline near the airport floatplane dock and extend northeast at least to Lewis Cove South (Figure 3B). Some algal species including laminarians, red algae, and green algae often grow within eelgrass beds, adding to the habitat diversity within the beds. However, because of a requirement for attachment to larger substrates, dense kelp beds typically exist in areas not occupied by eelgrass beds. Because these surveys took place in January, they should not be considered definitive in terms of the location or importance of eelgrass or kelp. For example, one of the primary kelp-bed forming species, bull kelp, is an annual, with highly reduced coverage and abundance in wintertime. More area-specific surveys should be conducted during the period from late spring through summer to map areas of interest.

Sea cucumbers, a commercially harvested species, were also present primarily in silty sand and gravel areas, sometimes within eelgrass beds. However, we also found sea cucumbers in deeper and more cobble-dominated habitats (Figures 3A through 3E).

In summary, the littoral resources of Tongass Narrows are typical of those found along semi-sheltered shorelines throughout southeast Alaska and in adjacent areas to the north and south. Some areas of the shorelines support harvestable quantities of hardshelled clams, and littoral areas include habitats of substantial ecological importance for a variety of marine resources. Healthy littoral areas with a mosaic of eelgrass and kelp beds are important to the early life history stages of commercially harvested crab and shrimp and to the early marine life history of anadromous salmonids. A variety of other species (e.g., sea ducks, marine mammals, terrestrial birds and mammals) also rely on these shorelines for a portion of their diets.

5.0 References

Fonseca, M.S. 1992. Restoring the seagrass systems in the United States. Pages 79-110 *in* G.W. Thayer, editor. Restoring the nation's marine environment. Maryland Sea Grant, College Park, Maryland.

Gabrielson, P.W., R.F. Scagel, and T. B. Widdowson. 1989. Keys to the benthic marine algae and seagrasses of British Columbia, Southeast Alaska, Washington, and Oregon. University of British Columbia, Vancouver, BC, Canada.

Lindstrom, S.C., and R.E. Foreman. 1978. Seaweed associations of the Flat Top Islands, British Columbia: a comparison of community methods. Syesis 11:171-185.

Lindstrom, S.C., J.L. Olsen, and W.T. Stam. 1997. Postglacial recolonization and the biogeography of *Palmaria mollis* (Rhodophyta) along the Northeast Pacific coast. Canadian Journal of Botany 75:1887-1896.

McRoy, C.P. 1970. Standing stocks and other features of eelgrass (*Zostera marina*) populations on the coast of Alaska. Journal Fisheries Research Board of Canada 27(10):1811-1821.

O'Clair, R.M., and C.E. O'Clair. 1998. Southeast Alaska's rocky shores: animals. Plant Press, Auke Bay, Alaska.

O'Clair, R.M., S.C. Lindstrom, and I.R. Brodo. 1996. Southeast Alaska's rocky shores: seaweeds and lichens. Plant Press, Auke Bay, Alaska.

Paine, R.T. 1966. Food web complexity and species diversity. American Naturalist 100:65-75.

Phillips, R.C. 1984. The ecology of eelgrass meadows in the Pacific Northwest: a community profile. US Fish and Wildlife Service, FWS/OBS-84/24, Washington, DC.

Quast, J.C. 1968. New records of 13 cottoid and blennioid fishes for southeastern Alaska. Pacific Science 22:482-487.

Ricketts, E.F., and J. Calvin. 1962. Between Pacific tides. 3rd edition, revised. Revisions by J. W. Hedgpeth. Stanford University Press, Stanford, California

Scagel, R.F., P.W. Gabrielson, D.J. Garbary, L. Golden, M.W. Hawkes, S.C. Lindstrom, J.C. Oliveira, and T.B. Widdowson. 1989. A synopsis of the benthic marine algae of British Columbia, Southeast Alaska, Washington and Oregon. University of British Columbia, Phycological Contribution Number 3, ISBN 0-88865-462-6, Vancouver.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364 *in* V.S. Kennedy, editor. Estuarine comparisons. Academic Press, New York.

Figures

Appendix A—
Station Name Equivalents

APPENDIX A

STATION NAME EQUIVALENTS

Appendix A contains information on the correlation of crossing and site identifications used during the video field surveys and recorded on the videotapes and station names shown in Figure 2. These changes have made the original location names irrelevant to the present planning process. The relation of the audio notations on the videotapes, the new location names used on the survey maps in this report, and the videotape number are listed in Table 1 and Figures 2A through 2E along with the letter and number designations used in data presentations. The current sampling names are an abbreviation of the Gravina (GRA), Pennock (PEN), and Revillagigedo (REV) island names along with a descriptive name of the location.

Table 1 Original and revised survey location nomenclature (see Figure 1).

Old Crossing Name	New Survey Location Name	Videotape Number
A North	REV-1 Refuge Beach	3
A South	GRV-1 Ohio Point	2
Channel Island	Channel Island	2
Danger Island	Danger Island	2
B North	REV-2 Floatplane Dock	3
B South	GRV-2 1-Mile Range	2
D North	REV-3 Propane Dock	3
D South	GRV-3 Lewis Cove N	3
C2 North	REV-4 North Dump	4
D South	GRV-4 Lewis Cove S	3
C1 South	GRV-5 Barge Dock	3
C1 North	REV-5 Riprap Cove	4
C2 South	GRV-6 Airport	3
E North	REV-6 Bar Point	1
E South	GRV-7 East Clump Island	1
E Deep	E Deep	5
F1 East Channel, North	REV-7 Thomas Basin	4
F1 East Channel, South	PENN-1 Radenbough Cove	4
F2 East Channel, North	REV-8 South Dump	2
F2 East Channel, South	PEN-2 East Channel SW	5
F1 West Channel, North	PEN-3 West Channel NE	1
F1 West Channel, South	GRV-8 Tugboat	5
F2 West Channel, North	PEN-4 West Channel SE	1
F2 West Channel, South	GRV-9 West Channel SW	1

Appendix B—
Intertidal Species Lists

APPENDIX B

INTERTIDAL SPECIES LISTS

In the following tables, the relative abundance of each taxon observed at the Gravina Access project site is indicated either with a letter code or a number. Letter codes are as follows:

A – abundant (typically more than about 20 percent cover or 20/0.25 m^2)

C – common (typically between about 5 to 20 percent cover or 5 to 20/0.25 m^2)

P – present (typically between about 1 to 5 percent cover or 1 to 5/0.25 m^2)

R – rare (typically less than 1 percent cover or 1/0.25 m^2)

Plants are provided in terms of percent cover using the codes above, unless a specific number is given. Numbers indicate that an actual quadrat was used to perform an estimate of number. Animals are provided either as percent cover or number using the codes above. Again, an actual number provided indicates than a quadrat estimate was performed.

It should be noted that larger animals (such as sea stars), because of their greater influence on the community, were considered to be abundant or common at densities below those listed above. Plants were typically not categorized as "rare" because of the time of the year of the surveys; in winter most plants are expected to be found at abundances well below those present at other times of the year.